INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(54) Title: TRANSMISSION SYSTEM WITH IMPROVED SIGNAL CONDITIONING MEANS
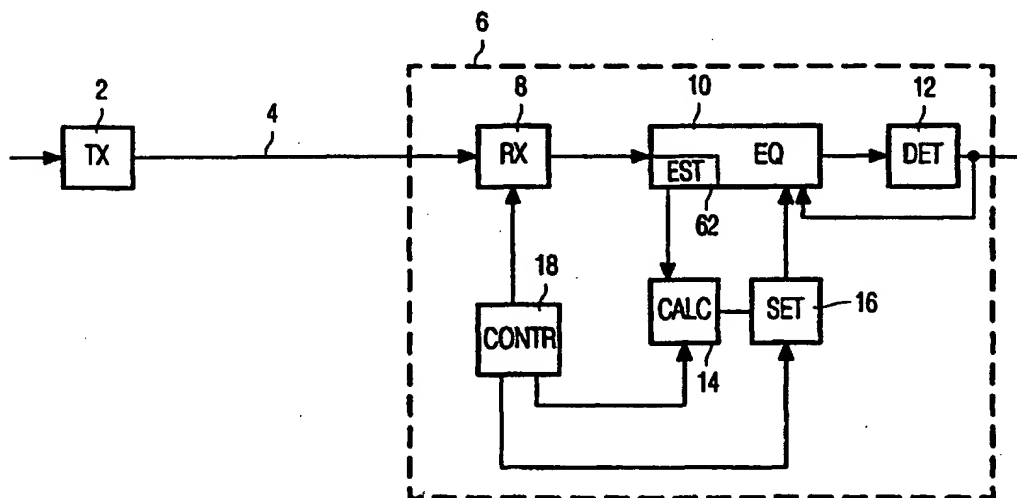
(57) Abstract

In a transmission system a signal is transmitted by a primary station (2) to a secondary station (6) via a transmission medium (4). The secondary station comprises a tunable receiver (8) for tuning to a signal received from the transmission medium. The receiver also comprises signal conditioning means such as an equalizer (10) with channel estimation means (62) for determining at least one property of the transmission channel. According to the present invention, the determined property is used for setting the signal conditioning means at a later instant. This can be at the change of frequency where the settings for the signal conditioning means (10) for the new frequency are calculated from the determined property. It is also possible that the property is stored for later use when the receiver (8) returns to the previous frequency. It is also possible that the determined property is used for determining the setting of signal conditioning means (20) which comprise a pre–equalizer (20) used with transmitter (22) in the secondary station.

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Transmission system with improved signal conditioning means.

The present invention relates to a transmission system comprising a primary terminal comprising a transmitter coupled via a transmission channel to a secondary terminal, the secondary terminal comprises channel estimation means for determining at least one transmission property of the transmission channel, the secondary terminal further comprises

5   signal conditioning means for conditioning a signal in said secondary terminal.

The present invention is also related to a receiver, signal conditioning means and a transmission and receiving method.

A transmission system according to the preamble is known from the book "Digital Communication", by E.A. Lee and D.G. Messerschmitt, chapter 9, "Adaptive

10   Equalization", pp. 371-378.

In transmission systems it can happen that the transmission channel has severe impairments making transmission of information without taking additional measures impossible. In such transmission systems it is often required that the receiver comprises signal-conditioning means, which are arranged for conditioning the signal, received from the

15   transmission medium. Such signal conditioning means can comprise an equalizer for equalizing the transfer function of the transmission medium. Such an equalizer is e.g. required when the signal received by the secondary terminal comprises echoes. These echoes can be caused by multipath transmission in a terrestrial transmission system or by incorrectly terminated coaxial cables in a CATV system.

20   The signal conditioning means can be realized in the time domain, e.g. by means of a transversal filter, or in the frequency domain, by performing an FFT, processing the FFT coefficients and subsequently performing an inverse FFT.

An object of the present invention is to provide a transmission system according to the preamble being improved in several aspects.

25   Therefor the present invention is characterized in that the secondary terminal comprising setting means for setting parameters of the signal conditioning means in dependence on a previously determined value of the transmission property.

By setting the parameters of the signal conditioning means in dependence on the previously determined transmission property, it becomes possible to prepare the signal

conditioning means for different circumstances such as a different frequency of the signal to be received. It is also possible to set the signal conditioning means used for conditioning a signal to be transmitted by the secondary terminal in dependence on the transmission property determined from the presently received signal.

5   The present invention is based on the recognition that if some information about the characteristics of the transmission channel is known, it is possible to determine from the transmission property the setting of the signal conditioning means. This information can be exploited to set the (initial) value of the coefficients of the signal conditioning means to more adequate value than is possible without using the information about the characteristics of the

10   transmission channel.

        An embodiment of the invention is characterized in that the secondary terminal comprises a receiver with adjustable tuning means for tuning the receiver to the frequency of the signal received from the transmission medium, in that the signal conditioning means are arranged for conditioning the signal received from the transmission medium, in that the tuning

15   means are arranged for switching to the further frequency, and in that the setting means are arranged for setting the parameters of the signal conditioning means for said further frequency at switching to said further frequency.

        The advantage of this embodiment is that the signal conditioning means are prepared for switching to a new frequency, resulting in the ability to perform a frequency

20   change rapidly. This is in particular important for digital TV receivers enabling fast "zapping".

        An embodiment of the invention is characterized in that the signal conditioning means are arranged as adaptive signal conditioning means, and in that the channel estimation means are arranged for determining the channel property from the parameters of the signal conditioning means after the parameters have converged to a final value.

25   An easy way of operating the channel estimation means is to take over the coefficients of the adaptive signal conditioning means after it has converged to a final state.

        A further embodiment of the invention is characterized in that the setting means are arranged for storing the parameters of the signal conditioning means for a plurality of frequencies to which the receiver is tunable, and in that the setting means are arranged for

30   setting the parameters of the signal conditioning means to the parameters previously stored for said frequency.

        By storing the coefficients of the equalizer for later use with the same frequency, an easy way of determining the initial coefficients of the equalizer is obtained. It is observed that in this case, it is advantageous to use an adaptive equalizer operating according

to the sign algorithm. An equalizer using the sign algorithm converges quicker than an equalizer using the LMS algorithm when the initial error is below a threshold value. If good starting values are available such as in the present invention, the initial error will in general smaller than said threshold value.

5   An alternative embodiment of the invention is characterized in that the secondary terminal comprises a transmitter for transmitting a signal on a frequency differing from the frequency of the signal received from the transmission medium and in that the signal conditioning means are arranged for conditioning the signal transmitted by the transmitter.

          With this embodiment it becomes possible to determine the setting of signal

10   conditioning means used for processing of a signal to be transmitted. By determining the coefficients for the signal conditioning means from the channel property determined by the channel estimation means, correct parameters for the signal conditioning means are obtained. This embodiment is based on the condition that there is a relation between the channel properties for the frequency for which the channel properties are determined, and the channel

15   properties for the frequency of the signal to be transmitted. This is in particular the case for a CATV system in which the main channel impairments are caused by reflections.

          The invention will now be explained with reference to the drawings.

20   Fig. 1 shows a first embodiment of a transmission system according to the present invention.

          Fig. 2 shows an embodiment of the invention where the secondary terminal comprises a transmitter.

          Fig. 3 shows a time domain implementation of the equalizer 10 according to

25   Fig. 1 or 2.

          Fig. 4 shows a frequency domain implementation of the equalizer 10 according to Fig1 or Fig. 2.

          Fig. 5 shows a flowgraph of a program for a programmable processor for implementing the setting means for use with a time domain equalizer.

30   Fig. 6 show a flowgraph of a program for a programmable processor for implementing the setting means for use with a frequency domain equalizer.

In the transmission system according to Fig. 1, the symbols to be transmitted are applied to an input of a transmitter 2 in a primary terminal 3. The output of the transmitter 2 is coupled via a transmission medium 4 to the secondary terminal 6. In the secondary terminal 6, the signal received from the transmission medium 4 is applied to a tunable receiver

5   8, which receives and demodulates the signal at its input. The output of the receiver 8 is connected to an input of the signal conditioning means, which is here an adaptive equalizer 10. The equalizer 10 is arranged for eliminating the inter-symbol interference, which is caused by the impairments of the transmission medium.

The adaptive equalizer 10 also comprises the channel estimation means 62 for

10   determining a transmission property of the transmission channel. This transmission property is here represented by the coefficients of the equalizer needed to equalize the transmission channel. An output signal present at a first output of the equalizer 10 is passed to an input of a detector 12, which derived detected symbol values from its input signal. The output of the detector 12 is connected to the output of the terminal 6 and to a second input of the equalizer

15   10.

A second output of the equalizer 10, carrying the coefficients of the adaptive equalizer provided by the channel establishing means 62, is coupled to a first input of a processor 14. The output of the processor 14 is connected to an input of the setting means 16. The output of the setting means 16 is connected to a third input of the equalizer 10 for the

20   coefficients to be set to said equalizer 10. A controller 18 controls the processor 14 and the setting means 16. The controller 18 is arranged for instructing the tuner 8 to change frequency in response to a command of a user. After the change of the frequency, the setting means 16 are instructed to pass the new initial coefficients to be used in the equalizer 10 to a third input of the equalizer.

25   In an embodiment of the present invention, the coefficients of the equalizer are stored together with an indication of the corresponding frequency in a memory just before the frequency switch is actually performed. This storing is performed for each of the frequencies to which the receiver can be tuned. After a frequency switch has been performed, the coefficients of the equalizer which were stored when the receiver was previously tuned at said

30   frequency, are retrieved from said memory and passed to the equalizer 10 by the setting means 16.

The transmission system according to Fig. 2 comprises besides the elements already present in the transmission system according to Fig. 1, additional elements 17, 20, 22 and 26. The filter 20 is present to provide pre-equalization of the signal to be transmitted by

the transmitter 22 in the secondary station to the receiver 26 in the primary station. The setting means 17 are arranged for setting the coefficients of the filter 20 in dependence on the transmission property determined by the channel estimator 62.

5   The equalizer 10 according to Fig. 3 is arranged for operating in the time domain. It comprises a common transversal filter having a plurality of interconnected delay elements 30 · · · · 40 and a plurality of multipliers 42 · · · · 56 with weighting coefficients w_1 · · · · w_N. The signals at the outputs of the multipliers 42 · · · · 56 are added by an adder 58. The output signal of the adder 58 is also the output signal of the equalizer 10. The output of the equalizer 10 and the output of the detector 12 are connected to inputs of a subtractor 60 which

10   calculates an error signal e[k] which is used as input signal for the adaptation process to be discussed. The output of the subtractor 60 is connected to an input of the channel estimation means, which are here constituted by adaptation means 62. The signals x[k] · · · · x[k-N] are also applied to inputs of the adaptation means 62. The adaptation means 62 are arranged for determining the coefficients w_1 · · · · w_N to minimize the correlation between the signal e[k]

15   and the signals x[k] · · · · x[k-N]. Each of the coefficients w_j is determined according to

$$w_j[k] = w_j[k-1] + \alpha \cdot e[k] \cdot x[k-j+1] \qquad (1)$$

In (1), α is an adaptation constant controlling the speed of convergence of the equalizer. Because in the present invention the coefficients of the equalizer are set to initial values close to the optimum value, the so-called sign algorithm can be used. A property of the sign algorithm is that it converges quicker than the LMS algorithm according to (1) when the initial

20   error is small. In the sign algorithm the coefficients w_j are determined according to:

$$w_j[k] = w_j[k-1] + \alpha \cdot SGN(e[k]) \cdot x[k-j+1] \qquad (2)$$

In (2) SGN indicates the sign function which determines the sign of its argument. The sign function equals to zero if its argument is zero.

In the equalizer 10 according to Fig. 4, the input signal is applied to an FFT unit 70, which calculates a Fast Fourier Transform from an input vector $\underline{x}$ [k] representing a block

25   of samples x[k] · · · · x[k-M] of the input signal. It is observed that the samples x[k] can be complex, in which the real part of x[k] is the in-phase component of a quadrature signal, and the imaginary part is the quadrature-phase component of the quadrature signal.

The output signal of the FFT unit 70 presents an output vector $\underline{X}$ [k], which represents the frequency spectrum of the input vector $\underline{x}$ [k]. The output vector $\underline{X}$ [k] of the

30   FFT unit 70 is applied to inputs of a multiplier unit 72 which is arranged for multiplying the input vector $\underline{X}$ [k] with a coefficient vector $\underline{W}$ [k] representing a block of coefficients

$w_1[k] \cdots \cdot w_M[k]$.

At the output of the multiplier a vector $\underline{Y}[k]$, representing a block of coefficients $Y_1[k] \cdots \cdot Y_N[k-M]$ is present. An Inverse Fast Fourier Transform unit 74 converts the output vector $\underline{Y}[k]$ into a vector $\underline{y}[k]$ which represents a block of output samples $y[k] \cdots$

5 $\cdot y[k-M]$. This block of output samples is converted to a serial stream of output samples, which is applied to the detector 12 and a first input of a subtractor 78. At the output of the detector 12 the detected output symbols are available. The output of the detector 12 is also connected to a second input of a subtractor 78 which determines an error signal e[k] from the input signal and the output signal of the detector 12. The error signal e[k] is applied to an input of channel

10 estimation means which are here an adaptation unit 76. Also the vector $\underline{X}[k]$ is applied to corresponding inputs of the adaptation means 76. The adaptation means 76 calculate the vector $\underline{W}[k]$ from the vector $\underline{X}[k]$ and the error signal e[k] according to:

$$\underline{W}[k+1] = \underline{W}[k] + \alpha \cdot \underline{X}^*[k] \cdot e[k] \qquad (3)$$

In (3) $\underline{X}^*[k]$ is the conjugate of the vector $\underline{X}[k]$ and α is an adaptation constant. The adaptation speed for all coefficients can be made equal by normalizing the second part of (3)

15 with respect to the power in each spectral bin. In such a case (3) changes into:

$$\underline{W}[k+1] = \underline{W}[k] + \alpha \cdot P^{-1}[k] \cdot \underline{X}^*[k] \cdot e[k] \qquad (4)$$

In (4) P^{-1} is a matrix which is obtained by inverting a matrix P having an estimate $E\{|X_l[k]|^2\}$ of the power in the frequency bins at its diagonal. P is defined as:

$$P = \begin{bmatrix} E\{|X_1[k]|^2\} & 0 & 0 & 0 & 0 \\ 0 & E\{|X_2[k]|^2\} & 0 & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & E\{|X_{M-1}[k]|^2\} & 0 \\ 0 & 0 & 0 & 0 & E\{|X_M[k]|^2\} \end{bmatrix} \qquad (5)$$

In the flow diagram according to Fig. 5, the numbered instructions have the following

20 meaning:

No.	Inscription	Meaning
80	BEGIN	The program is started
82	READ COEFFICIENTS	The coefficients of the equalizer are read
84	SELECT LARGEST 2	The largest two coefficients are selected
86	CALC DIFFERENCE	The difference between the largest coefficients is calculated
88	CRITERION MET ?	It is checked whether the coefficients correspond to the channel model.
90	KEEP COEFFICIENTS	Keep the coefficients of the equalizer at a frequency switch
92	INIT TO DEFAULT	Initialize the coefficients to a default setting at a frequency switch
94	END	The program is terminated.

The program according to the flowgraph of Fig. 5 is called when the controller 18 performs a frequency switch. The program according to Fig. 5 is to be used when the equalizer 10 is implemented according to Fig. 3. In instruction 80 the program is started and the used variables are initialized. In instruction 82 the processor 14 reads the present values of the coefficients $w_1 \cdots w_N$ from the equalizer 10. In instruction 84 the largest two coefficients are selected, and in instruction 86 the difference between the modulus of said coefficients is calculated. In instruction 88, it is checked whether the channel property represented by the coefficients of the equalizer 10 fit in the used channel model. If the difference between the modulus of said two largest coefficients is smaller than a reference value, it is assumed that a substantial reflection is present in the signal. Preferably, it also checked whether the remaining coefficients are substantially smaller than the two largest coefficients. If it is decided that a substantial reflection is present in the signal, the coefficients of the equalizer are not changed at the frequency switch, because the optimal time domain coefficients for compensating a large echo do not depend on the frequency of the signal to be received.

If in instruction 88 it is decided that no substantial reflection is present, in instruction 92 the coefficients of the equalizer 10 are set to a default value. The set of coefficients then comprises one main component, and the remaining coefficients are set to zero.

In the flow diagram according to Fig. 6, the numbered instructions have the following meaning:

No.	Inscription	Meaning
96	BEGIN	The program is started
98	READ COEFFICIENTS	The coefficients of the equalizer are read
100	CALC PS	The power spectrum is calculated
102	DET S_{MAX}, S_{MIN}	The maximum value and the minimum value of the power spectrum are calculated
104	$(S_{MAX}-S_{MIN})/S_{MAX} > \varepsilon$?	It is checked whether the transmission channel meets the channel model
106	FIND NEAREST NOTCHES	The new coefficients for the equalizer are calculated using the channel model
108	CALC $\Delta\omega$	The difference between two spectral notches is calculated
110	CALC COEFF. SHIFT k	The needed coefficient shift value is calculated
112	SET SHIFTED COEFF.	The shifted coefficients are determined
114	SET DEFAULT COEFF.	Default coefficients are passed to the filter
116	END	The program is terminated

5   The program according to the flowgraph of Fig. 6 is called when the controller 18 performs a frequency switch. The program according to Fig. 6 is to be used when the equalizer 10 is implemented according to Fig. 4. In instruction 96 the program is started and the used variables are initialized. In instruction 98 the processor 14 reads the present values of the frequency domain coefficients $W_1 \cdots W_M$ from the equalizer 10. In instruction 100 the

10   power spectrum of the input signal is calculated from the filter coefficients. This is done according to:

$$S_i = \frac{1}{|W_i|^2} \quad ; \quad 1 \leq i \leq M \tag{6}$$

In instruction 102 the maximum value S_{MAX}, the minimum value S_{MIN} of the power spectrum S_i are determined. In instruction 104 it is checked whether the transmission property meets the channel model, by comparing the difference between S_{MAX} and S_{MIN} with a reference value ε. If the difference is smaller than ε, the channel model is not adequate, and the coefficients of the filter 72 will be set to a default value in instruction 114.

If the difference is larger than ε, the transmission channel can adequately be modeled by a multipath transmission model. Consequently, the initial coefficients for the equalizer can be calculated using a multipath transmission model. If the multipath transmission model is described by a direct path having a transfer function equal to 1 and a reflection path having a time delay τ and an amplitude transfer function β, the following can be written for the transfer function $H(\omega)$:

$$H(\omega) = 1 - \beta \cdot e^{-j\omega\tau} \qquad (7)$$

If it is assumed that the output signal of the transmitter has a white spectrum, the power spectrum $S(\omega)$ is equal to:

$$S(\omega) = |1 - \beta \cdot \cos(\omega\tau) - j \cdot \beta \cdot \sin(\omega\tau)|^2 = 1 + \beta^2 - 2 \cdot \beta \cdot \cos(\omega\tau) \qquad (8)$$

(8) describes a periodic spectrum having equally spaced peaks with an amplitude $1+\beta$ and notches with an amplitude $1-\beta$. This property of the spectrum will be used for determining the new coefficients of the filter 72. The relation between the parameters S_{MAX} and S_{MIN} and the channel property β is given by :

$$S_{MAX} = (1+\beta)^2 \qquad (9)$$
$$S_{MIN} = (1-\beta)^2$$

The frequency difference $\Delta\omega$ between two adjacent notches is equal to $2\pi/\tau$.

The M spectral values of the FFT transform performed by the FFT unit 70 cover a frequency range equal to the rate ω_S with which the output signal of the tuner is sampled. Consequently the relation between $\Delta\omega$ and Δi is given by:

$$\Delta\omega = \frac{\Delta i}{M} \cdot \omega_s \qquad (10)$$

If the tuner is tuned to an angular frequency ω_0, the FFT transform calculated by the FFT unit 70 covers angular frequencies from $\omega_0 - \frac{1}{2}\omega$ to $\omega_0 + \frac{1}{2}\omega_s$. In order to determine the new filter coefficients W_i to be used for a new angular frequency ω_1, in instruction 106 the two notches nearest to ω_0 are determined. This is done by searching two values of i_{MIN}. This search is started from $i=M/2$ which corresponds to an angular frequency of ω_0. The search is

arranged to find the first value i_{MIN1} smaller than M/2 and the first value i_{MIN2} larger than M/2. From the values i_{MIN1} and i_{MIN2} the value of $\Delta\omega$ can be calculated according to **(10)** using $\Delta i = i_{MIN2} - i_{MIN1}$.

After the tuner has been tuned to an angular frequency ω_1 the distance between the tuning frequency and the nearest notch has changed. This change $\Delta\theta$ can be calculated according to:

$$\Delta\theta = \left(\frac{\omega_0 - \omega_1}{\Delta\omega}\right) - ROUND\left(\frac{\omega_0 - \omega_1}{\Delta\omega}\right) \tag{11}$$

In **(11)** the function ROUND represents the integer value nearest to its argument. If the argument is exactly between two integers, it can be rounded to the largest integer. The value $\Delta\theta$ represents a shift of the frequency spectrum of the input signal of the equalizer. Because the only change in the spectrum of the input signal of the equalizer is a frequency shift, the optimum values of the adaptive filter can also be obtained by a simple frequency shift. In a frequency domain filter, the coefficients have to be shifted over a frequency corresponding to $\Delta\theta$. The shift $\Delta\theta$ can be realized by replacing the coefficients W_i by coefficients W_{i+k}. The value of this shift k is calculated in instruction 110 according to $k = M \cdot \dfrac{\Delta\theta}{\omega_s}$. In instruction 112, the coefficients W_i are replaced by the coefficients W_{i+k}. If i+k becomes negative, the coefficients W_i are replaced by $W_{i+k+\Delta i}$. If i+k becomes larger than M, the coefficients W_i are replaced by $W_{i+k-\Delta i}$.

After the new coefficients W_i have been set, the program is terminated.

CLAIMS:

1.   Transmission system comprising a primary terminal comprising a transmitter coupled via a transmission channel to a secondary terminal, the secondary terminal comprises channel estimation means for determining at least one transmission property of the transmission channel, the secondary terminal further comprises signal conditioning means for
5   conditioning a signal in said secondary terminal in dependence on said transmission property, characterized in that the secondary terminal comprising setting means for setting parameters of the signal conditioning means in dependence on a previously determined value of the transmission property

10   2.   Transmission system according to claim 1, characterized in that the secondary terminal comprises a receiver with adjustable tuning means for tuning the receiver to the frequency of the signal received from the transmission medium, in that the signal conditioning means are arranged for conditioning the signal received from the transmission medium, in that the tuning means are arranged for switching to the further frequency, and in that the setting
15   means are arranged for setting the parameters of the signal conditioning means for said further frequency at switching to said further frequency.

3.   Transmission system according to claim 1 or 2, characterized in that the signal conditioning means are arranged as adaptive signal conditioning means, and in that the
20   channel estimation means are arranged for determining the channel property from the parameters of the signal conditioning means after the parameters have converged to a final value.

4.   Transmission system according to claim 2, characterized in that the setting
25   means are arranged for storing the parameters of the signal conditioning means for a plurality of frequencies to which the receiver is tunable, and in that the setting means are arranged for setting the parameters of the signal conditioning means to the parameters previously stored for said frequency.

5.   Transmission system according to claim 4, characterized in that the signal conditioning means are arranged as adaptive signal conditioning means, and in that the setting means are arranged for storing the parameters of the signal conditioning means after the parameters have converged to a final value.

5

6.   Transmission system according to claim 1, characterized in that the secondary terminal comprises a transmitter for transmitting a signal on a frequency differing from the frequency of the signal received from the transmission medium and in that the signal conditioning means are arranged for conditioning the signal transmitted by the transmitter.

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7.   Transmission system according to one of the claims 1, 2, or 3 characterized in that the setting means are arranged for calculating the parameters of the signal conditioning means in dependence on previously determined parameters of the signal conditioning means by using a model of the transmission medium.

15

8.   Transmission system according to claim 4, characterized in that the model comprises a multi-path transmission model.

9.   Transmission system according to claim 5, characterized in that the multi-path
20   transmission model comprises one direct path and one indirect path.

10.   Terminal comprising a receiver for receiving a signal from a transmission channel, the terminal comprises channel estimation means for determining at least one transmission property of the transmission channel, the terminal further comprises signal
25   conditioning means for conditioning a signal in said secondary terminal in dependence on said transmission property, characterized in that the secondary terminal comprising setting means for setting parameters of the signal conditioning means in dependence on a previously determined value of the transmission property.

30   11.   Terminal according to claim 10, characterized in that the receiver comprising adjustable tuning means for tuning the receiver to the frequency of the signal received from the transmission medium, in that the signal conditioning means are arranged for conditioning the signal received from the transmission medium, in that the tuning means are arranged for switching to the further frequency, and in that the setting means are arranged for setting the

parameters of the signal conditioning means for said further frequency at switching to said further frequency.

12.   Terminal according to claim 10, characterized in that the terminal comprises a transmitter for transmitting a signal on a frequency differing from the frequency of the signal received from the transmission medium and in that the signal conditioning means are arranged for conditioning the signal transmitted by the transmitter.

13.   Transmission method for transmitting information from a primary terminal to a secondary terminal comprising a receiver via a transmission channel, the method comprises determining at least one transmission property of the transmission channel, and conditioning a signal in said secondary terminal in dependence on said transmission property, characterized in that the method comprises setting parameters of the signal conditioning means in dependence on a previously determined value of the transmission property.
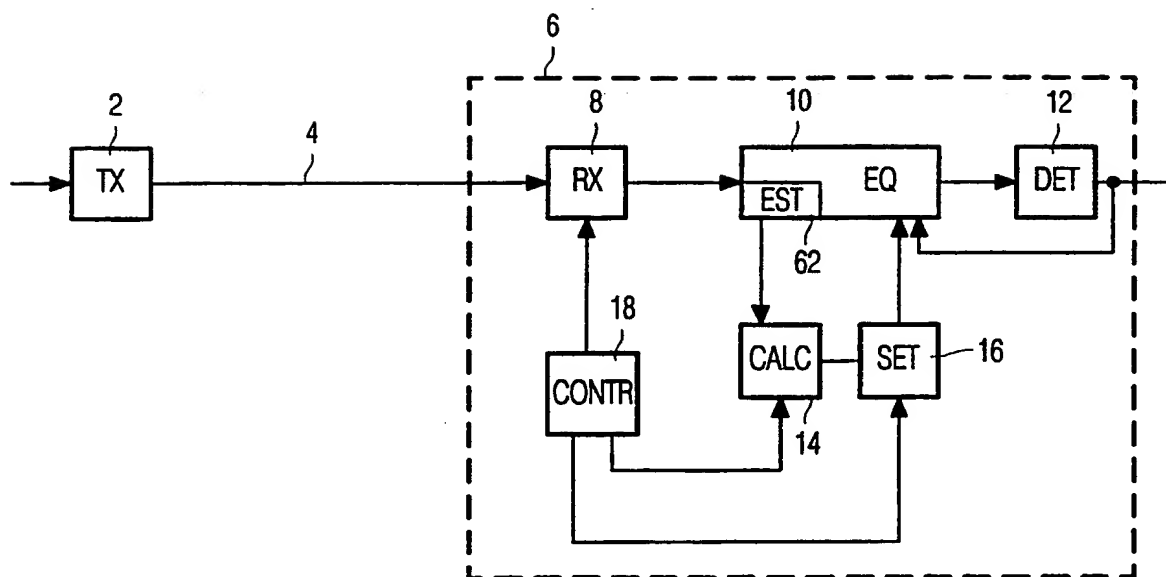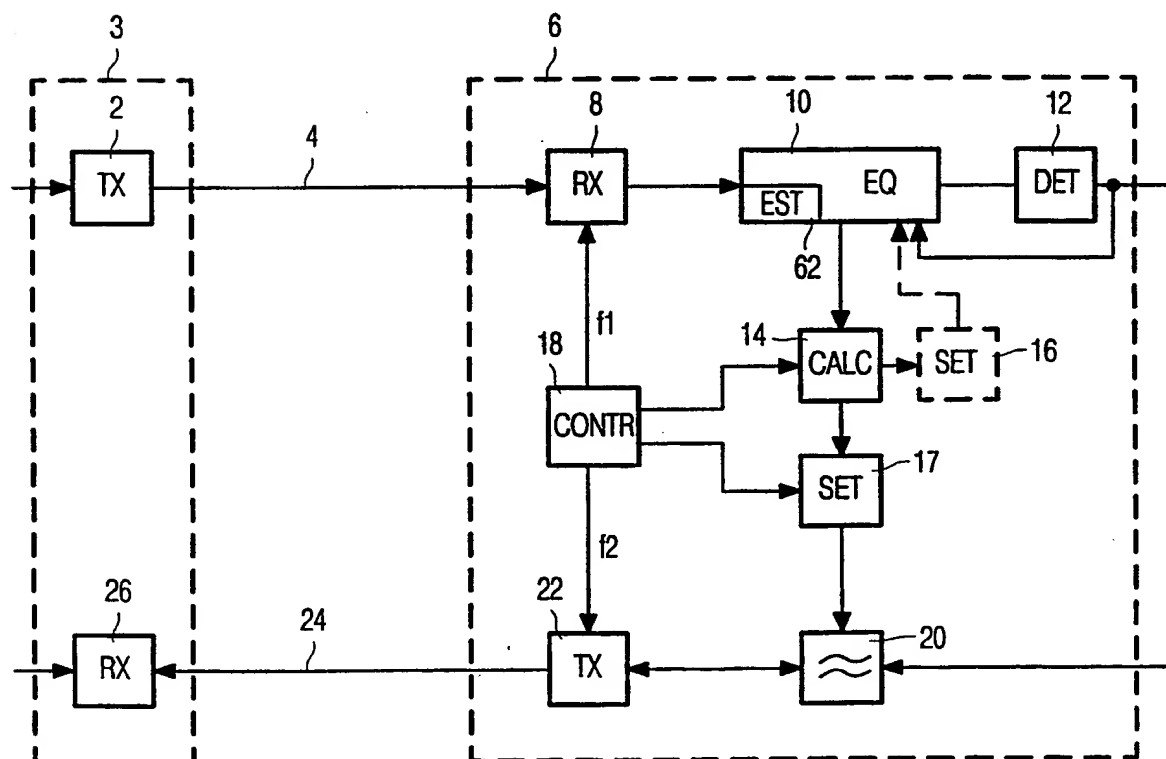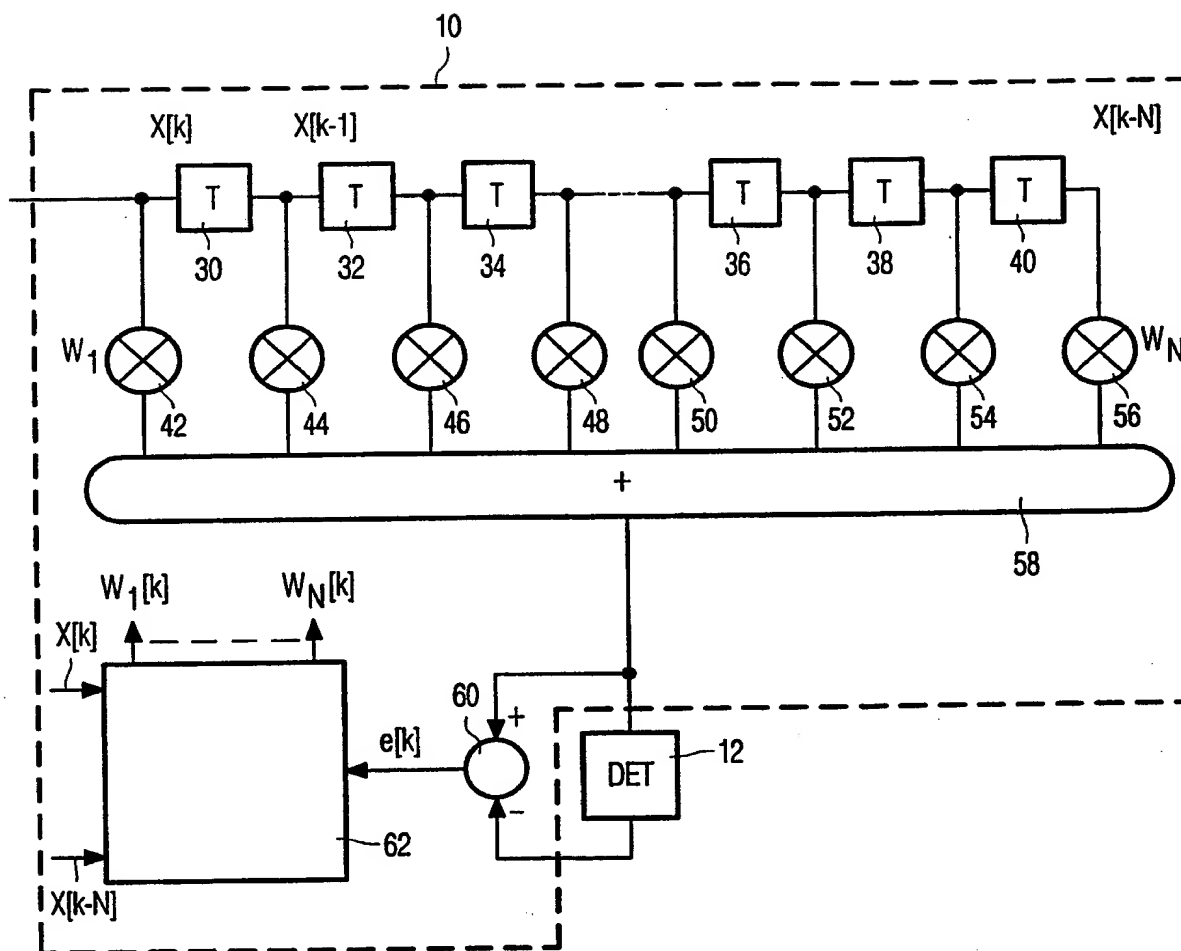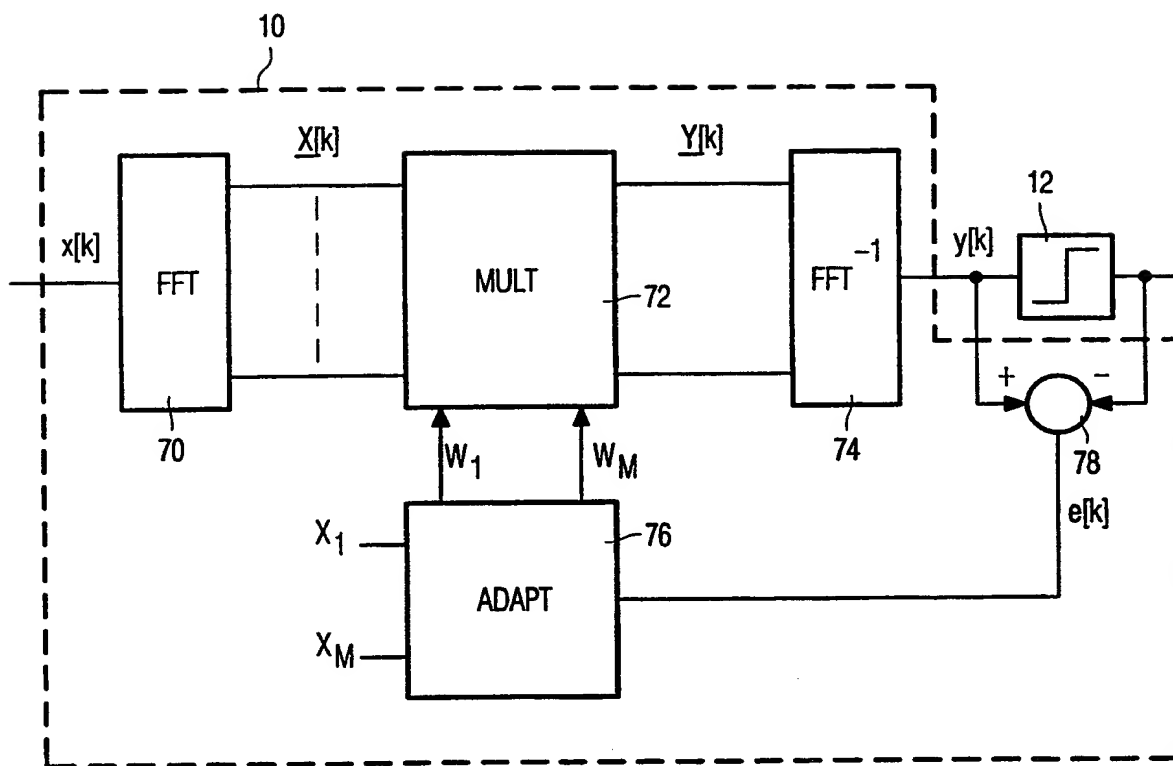
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FIG. 1

FIG. 2
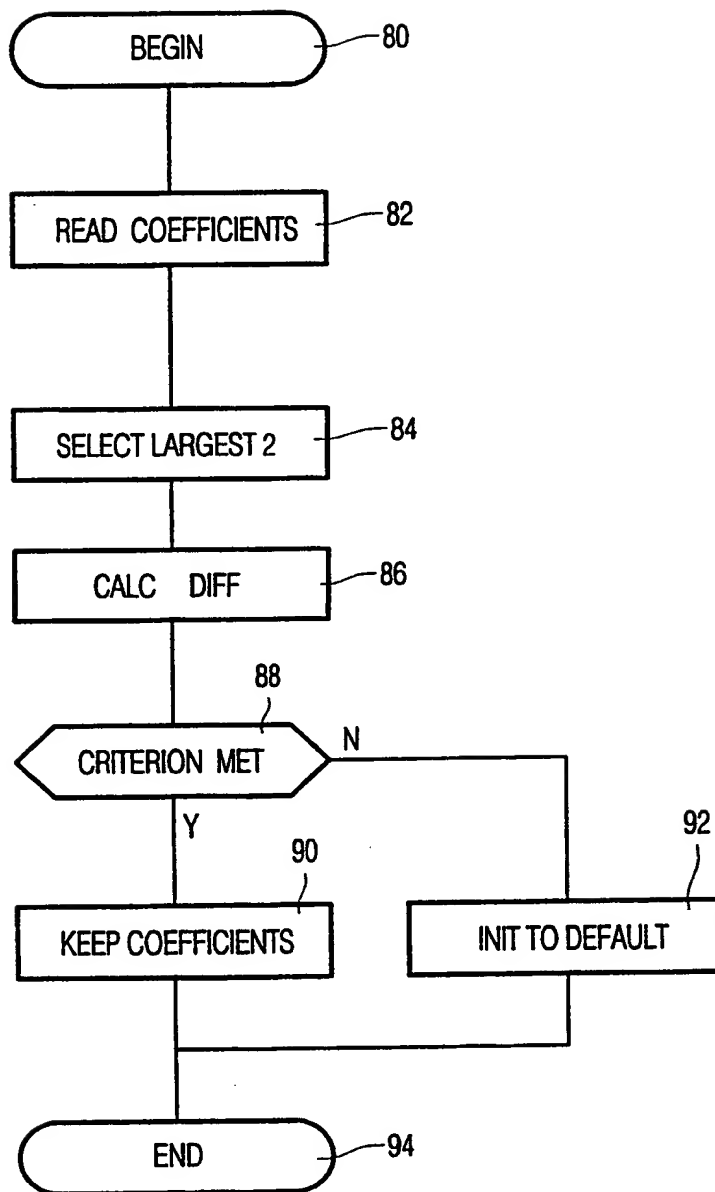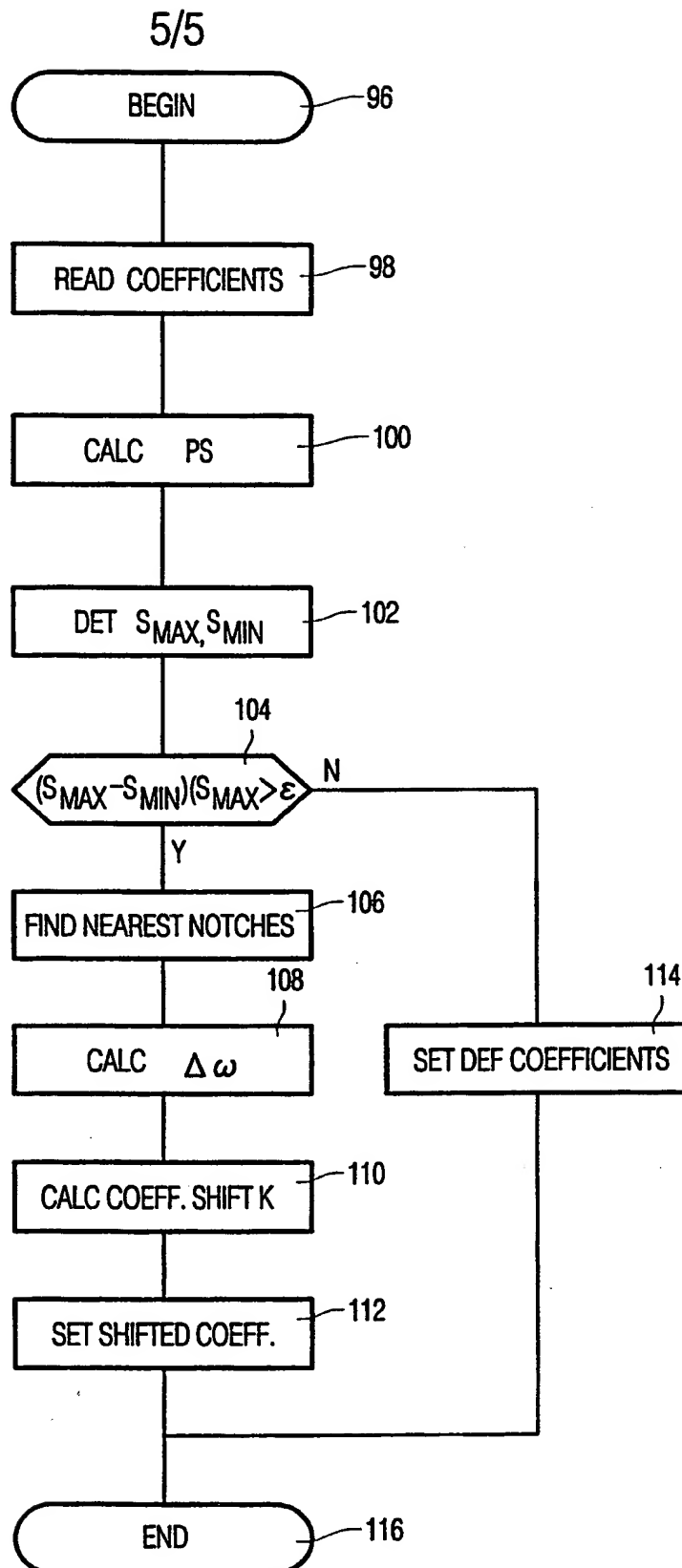
FIG. 3

FIG. 4

FIG. 5

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           ╭─────────────╮
          (    BEGIN       )────96
           ╰─────────────╯
                 │
         ┌───────────────────┐
         │ READ  COEFFICIENTS │────98
         └───────────────────┘
                 │
         ┌───────────────────┐
         │  CALC     PS       │────100
         └───────────────────┘
                 │
         ┌───────────────────┐
         │ DET  S_MAX,S_MIN   │────102
         └───────────────────┘
                 │         104
                 │
        ╱─────────────────────╲    N
       ⟨ (S_MAX-S_MIN)(S_MAX)>ε ⟩──────────┐
        ╲─────────────────────╱            │
                 │ Y                        │
         ┌───────────────────┐              │
         │ FIND NEAREST NOTCHES│────106      │
         └───────────────────┘              │
                 │         108              │    114
         ┌───────────────────┐      ┌──────────────────────┐
         │  CALC    Δω        │────  │ SET DEF COEFFICIENTS │
         └───────────────────┘      └──────────────────────┘
                 │                              │
         ┌───────────────────┐                  │
         │ CALC COEFF. SHIFT K │────110          │
         └───────────────────┘                  │
                 │                              │
         ┌───────────────────┐                  │
         │ SET SHIFTED COEFF. │────112           │
         └───────────────────┘                  │
                 │                              │
                 └──────────────────────────────┘
                 │
           ╭─────────────╮
          (    END        )────116
           ╰─────────────╯
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FIG. 6

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7   H04L25/03

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7   H04L   H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 663 765 A (DAE WOO ELECTRONICS CO LTD) 19 July 1995 (1995-07-19) abstract page 2, line 25 - line 33 page 3, line 20 - line 39 page 4, line 45 - line 55 ---	1-5,7-11
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X	EP 0 629 080 A (ST MICROELECTRONICS SRL) 14 December 1994 (1994-12-14) page 3, line 57 -page 4, line 1; claim 1 page 4, line 55 -page 5, line 3 ---	1-3,7, 10,11

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[X] Further documents are listed in the continuation of box C.   [X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 January 2000	02/02/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Binger, B

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INTERNATIONAL SEARCH REPORT

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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